Hochschule Worms
University of Applied Sciences

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SGR-Chain: Flexibility

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Objectives

- **What are the key objectives of this module?**

- After this module, you will be able to:
  - Understand the **benefits** of **resource flexibility**
  - Get to know strategies for **flexibility design**
  - Design **flexibility strategies** for a manufacturing network

Agenda

1 Principles on the benefits of resource flexibility

2 Case study: Flexibility design

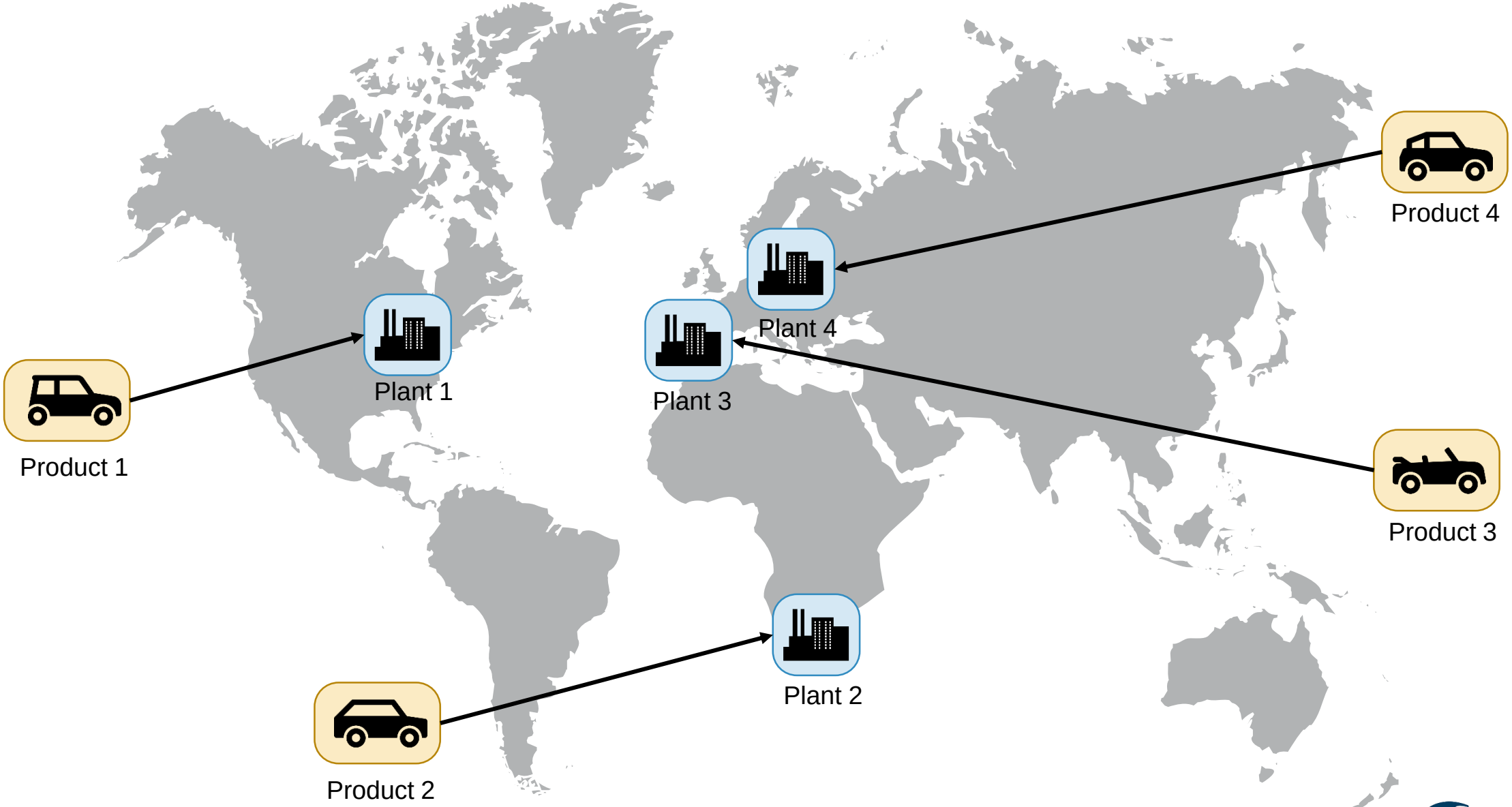
On the benefits of flexibility

- **“The initial investment [for flexibility] is slightly higher, but long-term costs are lower in multiplies”**
  - said Chris Bolen, manager of Ford’s Windsor engine plant, which uses the flexible system to machine new three-valve-per-cylinder heads for Ford’s 5.4-liter V8 engine... Ford says the system will help it meet changes in demand. “If our business was hit by a significant down-sizing from V8s to V6s or V6s to (four-cylinder engines) or diesels in North America, we’ll be able to react to that without years of turnaround“ said Kevin Bennett, Ford director of power train manufacturing. “It’s essential we be able to react to the market more rapidly than in the past.” (Chou et al., 2008)
- **Renault implements flexibility in its manufacturing network**
  - … “since demand can be unpredictable, industrial strategy must integrate flexibility“ said Michel Gornet, Renault’s manufacturing chief. (Automotive News Europe, 2007)

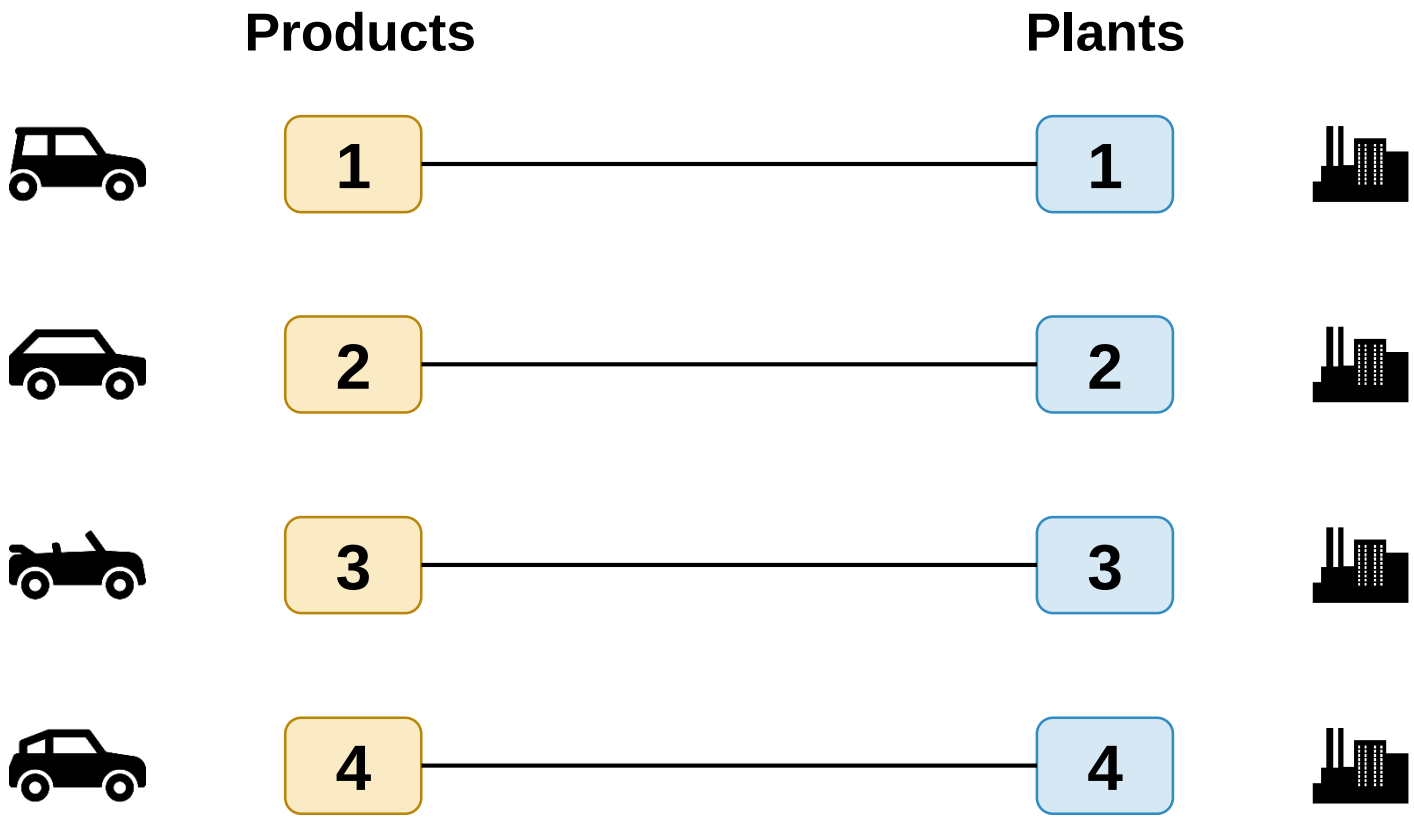
Resource flexibility

- **Resource flexibility** (also known as mix flexibility or process flexibility) can be defined as the number or variety of products or services that can be processed by one resource at the same time without incurring high transition penalties.
- **Applications of resource flexibility** include flexible manufacturing networks, cross-training of call center agents and workers at assembly lines, and resource sharing across industries through 3D printing or electronic platforms.

Plants and products in a global manufacturing network

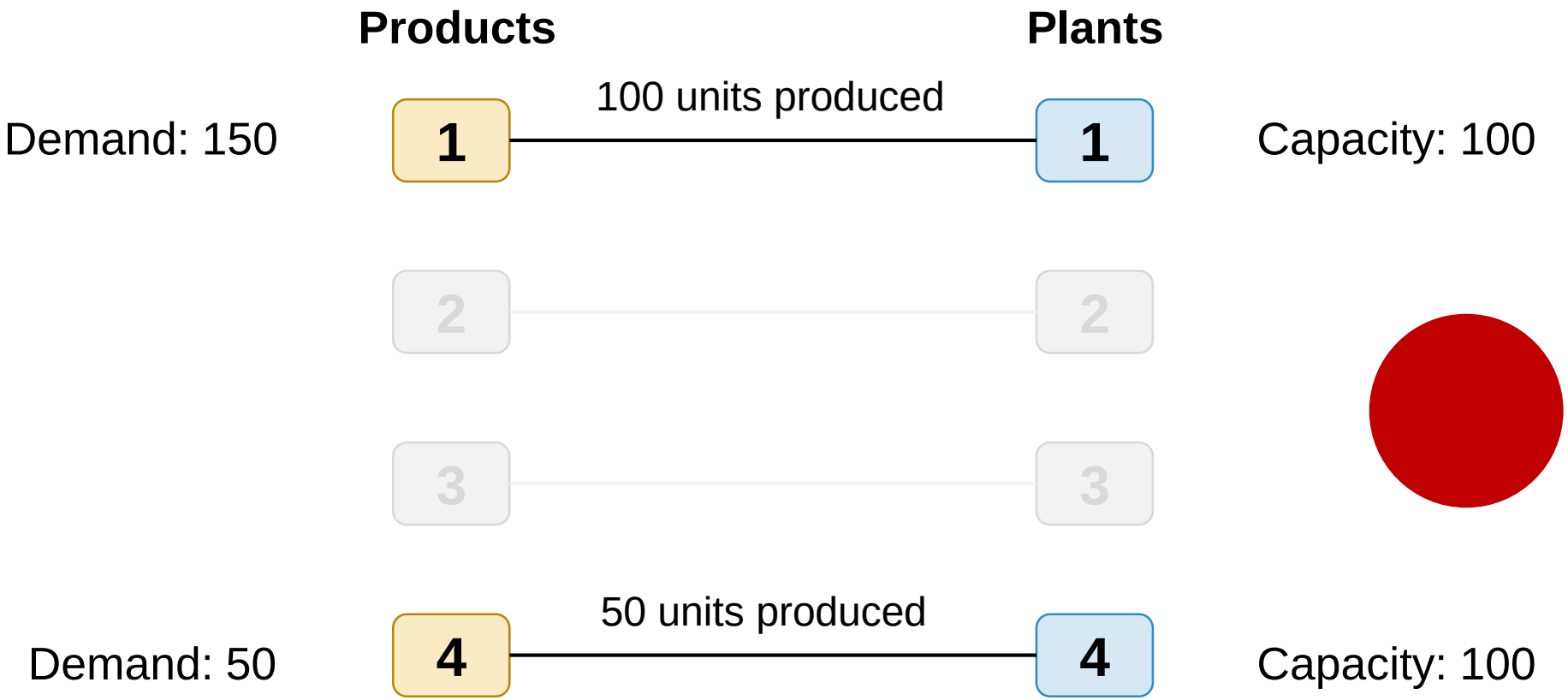


Plants and products: Schematic representation



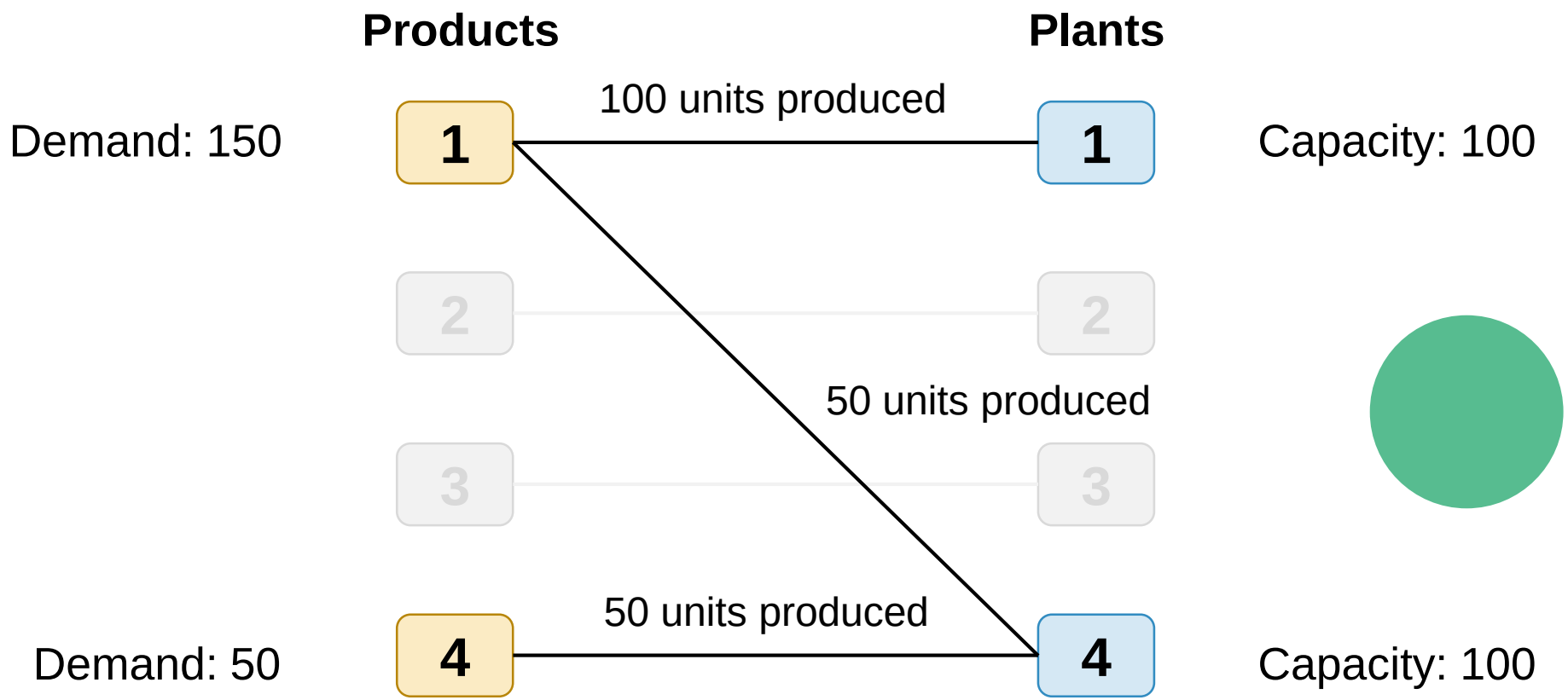
- Product-to-plant assignments indicate flexibility. Here, each product is exclusively assigned to one plant, thus the network exhibits no flexibility.

Without flexibility: Capacity-demand mismatches



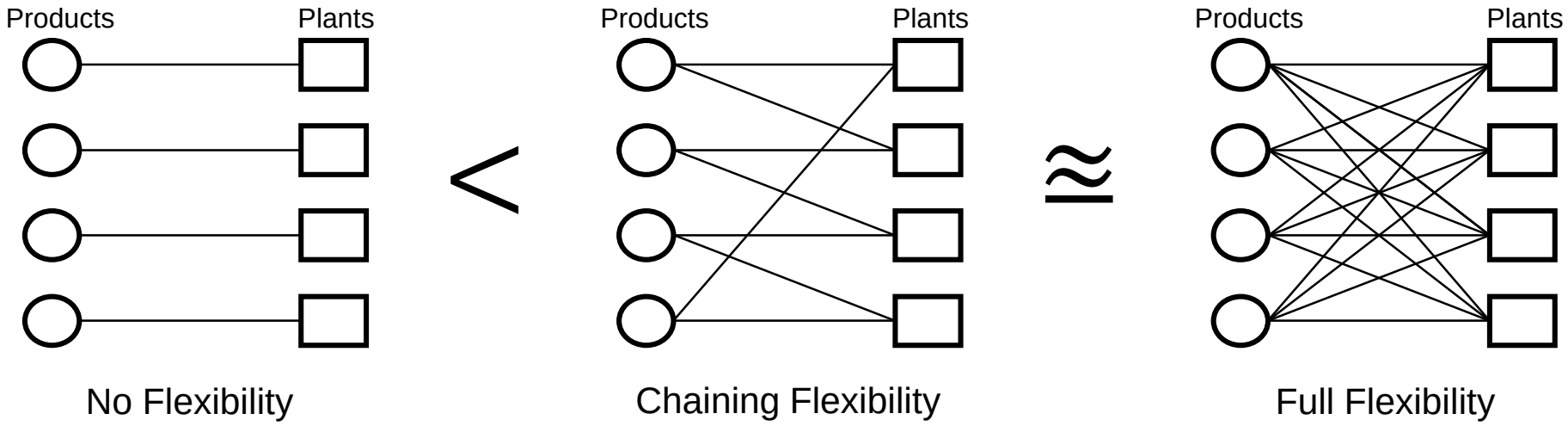
- The impact of demand fluctuations: Plant 1 cannot meet demand of product 1, while Plant 4 is underutilized.

With additional flexibility: All demands can be met



- If Product 1 can be built in Plant 1 and 4, idle capacity in plant 4 can be used to meet higher demand for product 1.

Where to add flexibility? Principles for designing flexibility by Jordan and Graves (1995)



- Limited flexibility (i.e., each plant builds only a few products), configured in the right way, yields most of the benefits of total flexibility (i.e., each plant builds all products)
- Limited flexibility has the greatest benefits when configured to chain products and plants together to the greatest extent possible.

References

- Jordan, W. C., and Graves, S. C. (1995). Principles on the benefits of manufacturing process flexibility. Management science, 41(4), 577-594.
- Chou, M. C., Teo, C. P., and Zheng, H. (2008). Process flexibility: design, evaluation, and applications. Flexible Services and Manufacturing Journal, 20, 59-94.

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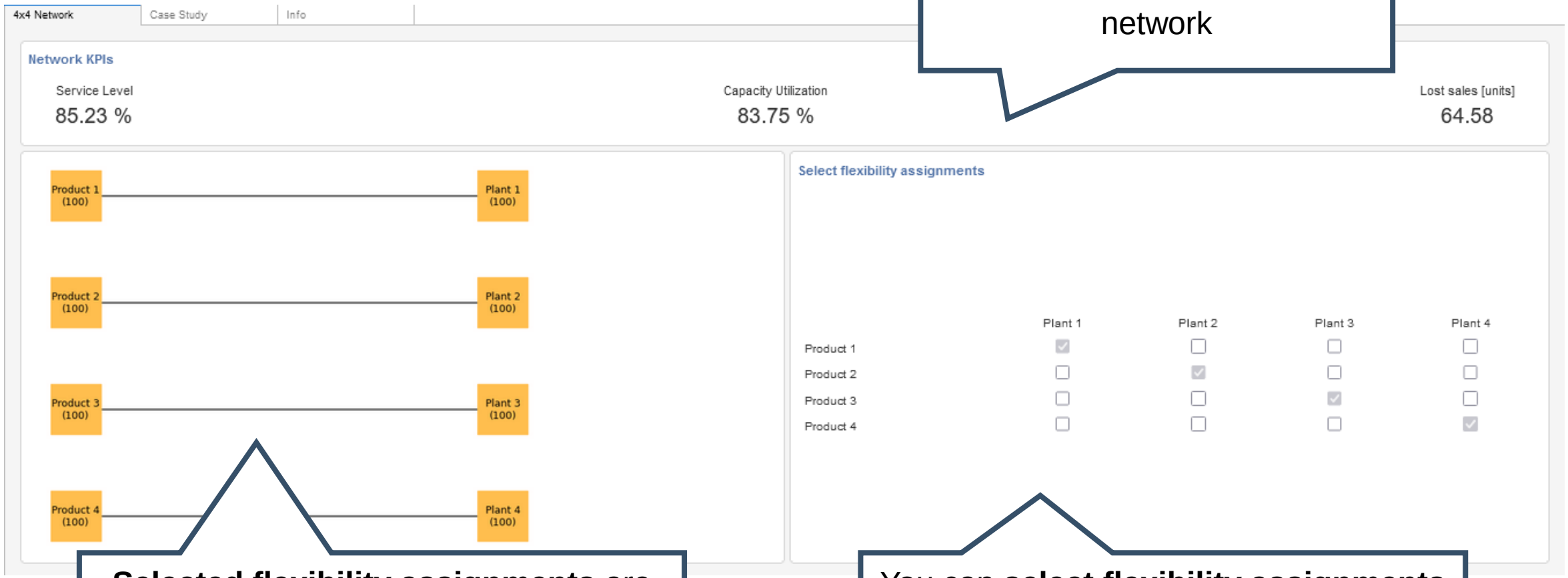
Interactive App: Principles of Designing for Flexibility

Background

- We continue by looking at the stylized example of the manufacturing network with four plants and four products. Average demand for all products and capacity for all plants is 100. Without uncertainty, the mean of demand is equal to capacity, so capacity would be sufficient to meet demand.
- We are interested in the performance of the manufacturing network if we factor in uncertainty. Using normally distributed demand with a mean of 100 and a standard deviation of 40, we use a simulation approach to evaluate the performance. We report three KPIs: Expected capacity utilization of the network, expected service level, and the expected lost sales, i.e., number of items (units) that were not available to meet demand.
- You can use the app to experiment with flexibility strategies. What are the highest benefits that can be achieved from flexibility, i.e., the value of a full flexibility design? How do chaining strategies perform against full flexibility?

The flexibility app, tab “4x4 network”



Performance KPIs of the network

Selected flexibility assignments are displayed here. The numbers in brackets denote mean demand and capacity.

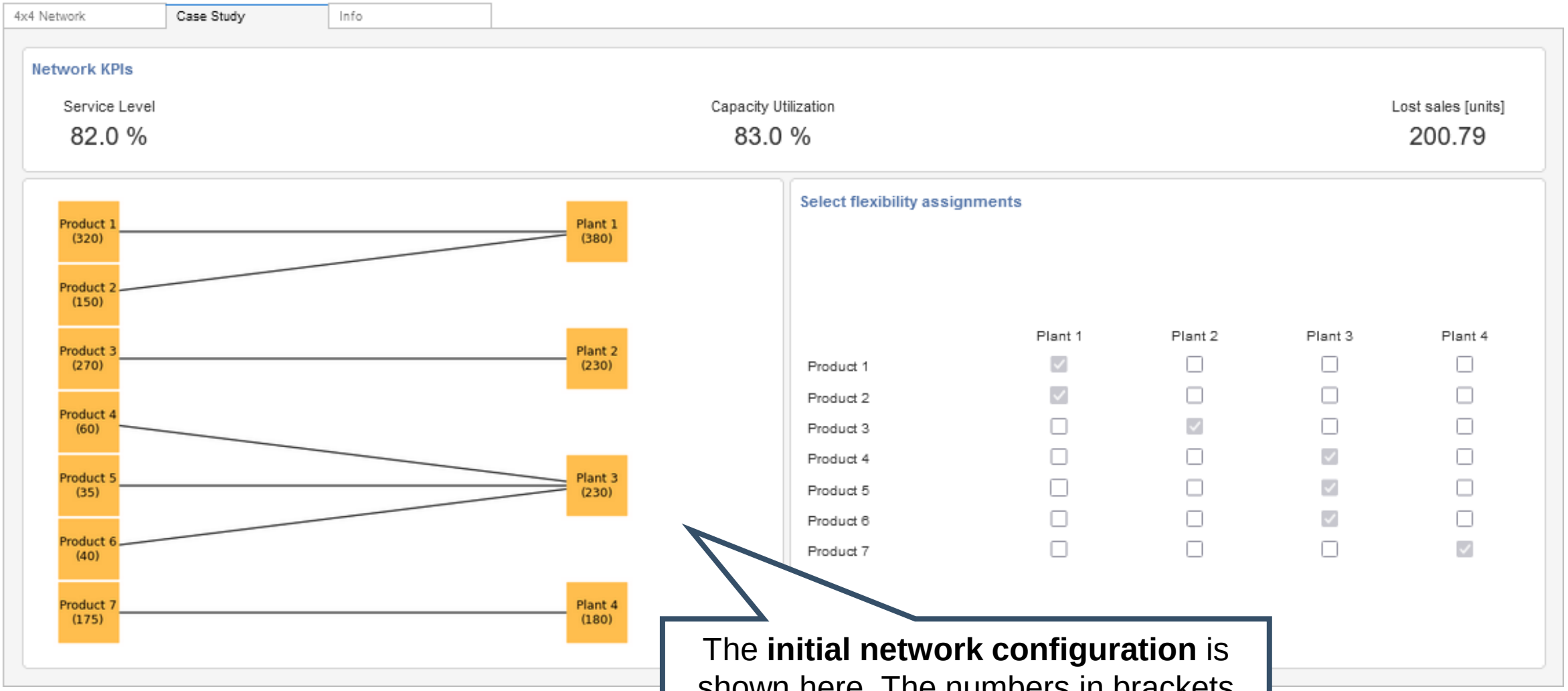
You can **select flexibility assignments** here. (Greyed-out boxes denote initial assignments that cannot be changed)

Interactive case study: Automotive Inc.

Case Background

- The case is inspired by a real set of vehicles and assembly plants at General Motors (Jordan and Graves, 1995). The product demand magnitudes and uncertainty levels are typical of those for automobiles at the nameplate level (e.g., Chevrolet Camaro). Additionally, the plant capacities used are representative of typical automobile assembly plants.
- The network cosmists seven vehicles and four assembly plants. We assume that product demands follow normally distributed random variables with a standard deviation equal to 40% of expected demand. We use a simulation model to calculate expected capacity utilization, service level, and lost sales for any given flexibility configuration.
- The objective is to improve expected network performance by adding just a few additional product-to-plant assignments.

The flexibility app, tab “Case study”



The **initial network configuration** is shown here. The numbers in brackets denote mean demand and capacity.

Flexibility design for Automotive Inc.: Tasks

Evaluate the maximum benefits of flexibility

- You can start by evaluating a full flexibility design, i.e., a configuration where vehicles can be manufactured in all assembly plants. This can serve as a benchmark for other designs (if your flexibility design comes close to the performance KPIs of a fully flexible design, you can be sure that there are no significant further improvements possible).

Design a limited flexibility design that yields virtually the same benefits as full flexibility

- Go back to the initial configuration of the network. You can develop a highly efficient flexibility design by following the chaining principles of Jordan and Graves. (Hint: You only need four additional product-to-plant assignments).